

We claim:

1           1.       A method for chemical mechanical polishing of tungsten comprising:  
2           providing a semiconductor substrate comprising on one face tungsten and a dielectric  
3           material;  
4           providing a chemical mechanical polishing composition comprising between about 2%  
5           and about 15% ammonium persulfate, between about 0.1% and about 10 % of a secondary  
6           oxidizer, a pH adjusting compound to adjust the pH of the composition, and optionally an  
7           abrasive, wherein the pH of the composition is between about 6.5 to about 12;  
8           movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9           psi pressure on the substrate and with the composition under conditions that tungsten is removed  
10          at a rate different than the removal of the dielectric material.

1           2.       The process of claim 1 wherein the secondary oxidizer comprises potassium  
2           peroxymonosulfate, peroxymonosulfuric acid, imidazole, malonic acid, or malonamide.

1           3.       The process of claim 1 wherein the chemical mechanical polishing composition  
2           comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1           4.       The process of claim 1, wherein the chemical mechanical composition comprises  
2           periodic acid, peracetic acid, oxalic acid, citric acid, lactic acid,  $\text{NH}_4\text{HF}_2$ , or a mixture thereof.

1           5.       The process of claim 1 wherein the secondary oxidizer comprises hydrogen  
2           peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

1           6.       The process of claim 1 wherein the chemical mechanical polishing composition  
2           additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3           acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1           7.       The process of claim 1 further comprising a second polishing operation  
2 comprising the steps of:

3           providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4 pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5 the pH of the composition is between about 3 to about 12;

6           movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7 psi pressure on the substrate and with the second composition under conditions that tungsten is  
8 removed at a rate different than the removal of the dielectric material.

1           8.       The process of claim 7 wherein the second chemical mechanical polishing  
2 composition comprises ammonium persulfate, a pH adjusting compound to adjust the pH of the  
3 composition, and optionally an abrasive, wherein the pH of the composition is between about 3  
4 to about 12.

1           9.       A method for chemical mechanical polishing of tungsten comprising:

2           providing a semiconductor substrate comprising on one face tungsten and a dielectric  
3 material;

4           providing a chemical mechanical polishing composition comprising between about 0.5%  
5 and about 10% periodic acid, between about 0.1% and about 10 % of a secondary oxidizer, a pH  
6 adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the  
7 pH of the composition is between about 4 to about 12;

8           movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9 psi pressure on the substrate and with the composition under conditions that tungsten is removed  
10 at a rate different than the removal of the dielectric material.

1           10.      The process of claim 9 wherein the secondary oxidizer comprises potassium  
2 peroxymonosulfate, imidazole, malonic acid, or malonamide.

1           11.      The process of claim 9 wherein the chemical mechanical polishing composition

2 comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1 12. The process of claim 9 wherein the chemical mechanical composition comprises  
2 ammonium persulfate, peracetic acid, oxalic acid,  $\text{NH}_4\text{HF}_2$ , or a mixture thereof.

1 13. The process of claim 9 wherein the secondary oxidizer comprises hydrogen  
2 peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

1 14. The process of claim 9 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1 15. The process of claim 9 further comprising a second polishing operation  
2 comprising the steps of:  
3 providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4 pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5 the pH of the composition is between about 3 to about 12;  
6 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7 psi pressure on the substrate and with the second composition under conditions that tungsten is  
8 removed at a rate different than the removal of the dielectric material.

1 16. The process of claim 9 wherein the second chemical mechanical polishing  
2 composition comprises 0.5% and about 10% periodic acid, a pH adjusting compound to adjust  
3 the pH of the composition, and optionally an abrasive, wherein the pH of the composition is  
4 between about 3 to about 12.

1 17. A method for chemical mechanical polishing of copper comprising:  
2 providing a semiconductor substrate comprising on one face copper and a dielectric  
3 material;

4 providing a chemical mechanical polishing composition comprising between about 1%  
5 and about 20% hydroxylamine, hydroxylamine sulfate, hydroxylamine nitrate, or mixture thereof,  
6 between about 0.1% and about 10 % of a carboxylic acid, a pH adjusting compound to adjust the  
7 pH of the composition, and optionally an abrasive, wherein the pH of the composition is between  
8 about 3 to about 12;

9 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
10 psi pressure on the substrate and with the composition under conditions that copper is removed at  
11 a rate different than the removal of the dielectric material.

1 18. The process of claim 17 wherein the chemical mechanical polishing composition  
2 comprises potassium peroxymonosulfate, imidazole, malonic acid, or malonamide, and wherein  
3 the second material is a dielectric material.

1 19. The process of claim 17 wherein the chemical mechanical polishing composition  
2 comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1 20. The process of claim 17 wherein the chemical mechanical composition comprises  
2 periodic acid, peracetic acid, oxalic acid,  $\text{NH}_4\text{HF}_2$ , or a mixture thereof.

1 21. The process of claim 17 wherein the secondary oxidizer comprises hydrogen  
2 peroxide, a perborate, a peroxyhydrate, or a urea hydrogen peroxide complex.

1 22. The process of claim 17 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1 23. The process of claim 17 further comprising a second polishing operation  
2 comprising the steps of:  
3 providing a second chemical mechanical polishing composition comprising an oxidizer, a

pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the pH of the composition is between about 3 to about 12;  
movably contacting the substrate face with a pad exerting between about 0.1 and about 9 psi pressure on the substrate and with the second composition under conditions that copper is removed at a rate different than the removal of the dielectric material.

24. The process of claim 17 wherein the second chemical mechanical polishing composition comprises hydroxylamine or a salt thereof, a pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the pH of the composition is between about 3 to about 12.

25. A method for chemical mechanical polishing of aluminum comprising:  
providing a semiconductor substrate comprising on one face aluminum and a dielectric material;  
providing a chemical mechanical polishing composition comprising between about 2% and about 12% ammonium persulfate, a pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the pH of the composition is between about 2 to about 8;  
movably contacting the substrate face with a pad exerting between about 0.1 and about 9 psi pressure on the substrate and with the composition under conditions that aluminum is removed at a rate different than the removal of the dielectric material.

26. The process of claim 25 wherein the chemical mechanical polishing composition comprises potassium peroxymonosulfate, peroxymonosulfuric acid, imidazole, malonic acid, or mixture thereof.

27. The process of claim 25 wherein the chemical mechanical polishing composition comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1 28. The process of claim 25, wherein the chemical mechanical composition comprises  
2 periodic acid, peracetic acid, oxalic acid, citric acid, lactic acid,  $\text{NH}_4\text{HF}_2$ , or a mixture thereof.

1 29. The process of claim 25 wherein the chemical mechanical polishing composition  
2 comprises hydrogen peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

1 30. The process of claim 25 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1 31. The process of claim 25 further comprising a second polishing operation  
2 comprising the steps of:

3 providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4 pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5 the pH of the composition is between about 3 to about 12;

6 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7 psi pressure on the substrate and with the second composition under conditions that alumina is  
8 removed at a rate different than the removal of the dielectric material.

1 32. The process of claim 25 wherein the second chemical mechanical polishing  
2 composition comprises ammonium persulfate, a pH adjusting compound to adjust the pH of the  
3 composition, and optionally an abrasive, wherein the pH of the composition is between about 3  
4 to about 12.

1 33. A method for chemical mechanical polishing of a substrate comprising:

2 providing a semiconductor substrate comprising on one face a metal and a dielectric  
3 material;

4 providing a chemical mechanical polishing composition comprising between about 0.1%  
5 and about 10% of ammonium hydroxide,  $\text{NH}_4\text{HF}_2$ , peracetic acid, or mixture thereof, a pH

adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the pH of the composition is between about 2 to about 13;

movably contacting the substrate face with a pad exerting between about 0.1 and about 9 psi pressure on the substrate and with the composition under conditions that metal is removed at a rate different than the removal of the dielectric material.

34. The process of claim 33 wherein the chemical mechanical polishing composition comprises potassium peroxymonosulfate, peroxymonosulfuric acid, imidazole, malonic acid, or malonamide.

35. The process of claim 33 wherein the chemical mechanical polishing composition comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

36. The process of claim 33, wherein the chemical mechanical composition comprises periodic acid, peracetic acid, oxalic acid, citric acid, lactic acid, or a mixture thereof.

37. The process of claim 33 wherein the chemical mechanical polishing composition comprises hydrogen peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

38. The process of claim 33 wherein the chemical mechanical polishing composition additionally comprises an organic acid selected from the group consisting of gluconic, malonic acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

39. The process of claim 33 further comprising a second polishing operation comprising the steps of:

providing a second chemical mechanical polishing composition comprising an oxidizer, a pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the pH of the composition is between about 3 to about 12;

movably contacting the substrate face with a pad exerting between about 0.1 and about 9

psi pressure on the substrate and with the second composition under conditions that the metal is removed at a rate different than the removal of the dielectric material.

40. A method for chemical mechanical polishing of copper comprising:  
providing a semiconductor substrate comprising on one face copper and a dielectric material;  
providing a chemical mechanical polishing composition comprising between about 0.1% and about 10% ammonium persulfate, at least one of a secondary oxidizer, an organic acid, or a chelating agent, a pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the pH of the composition is between about 3 to about 8;  
movably contacting the substrate face with a pad exerting between about 0.1 and about 9 psi pressure on the tungsten substrate and with the composition under conditions that tungsten is removed at a rate different than the removal of the dielectric material.

41. The process of claim 40 wherein the secondary oxidizer comprises potassium peroxymonosulfate, imidazole, malonic acid, potassium iodate, potassium periodate, lithium periodate, or malonamide, periodic acid, oxalic acid, and wherein the second material is a dielectric material.

42. The process of claim 41 wherein the chemical mechanical polishing composition additionally comprises an organic acid selected from the group consisting of gluconic, malonic acid, lactic acid, succinic acid, tartaric acid, citric acid, or salts thereof.

43. A method for chemical mechanical polishing of tungsten comprising:  
providing a semiconductor substrate comprising on one face tungsten and a dielectric material;  
providing a chemical mechanical polishing composition comprising between about 2% and about 20% hydroxylamine, between about 0.1% and about 10 % of a secondary oxidizer, a pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein



the pH of the composition is between about 7 to about 12;

movably contacting the substrate face with a pad exerting between about 0.1 and about 9 psi pressure on the substrate and with the composition under conditions that tungsten is removed at a rate different than the removal of the dielectric material.

44. The process of claim 43 wherein the secondary oxidizer comprises potassium peroxymonosulfate, peroxymonosulfuric acid, imidazole, malonic acid, or malonamide.

45. The process of claim 43 wherein the chemical mechanical polishing composition comprises at least one of potassium iodate, periodic acid, peracetic acid, potassium periodate,  $\text{NH}_4\text{HF}_2$ , or lithium periodate.

46. The process of claim 43 wherein the secondary oxidizer comprises hydrogen peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

47. The process of claim 43 wherein the chemical mechanical polishing composition additionally comprises an organic acid selected from the group consisting of gluconic, malonic acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, citric acid, or salts thereof.